

ROTARY INCUBATORS

Continuing with the general description of the assay procedure, following sufficient temperature ramp-up in a ramping station 700, the right-side transport mechanism 500 retrieves the MTU from the ramping station 700 and places the MTU 160 into the target capture and annealing incubator 600. In a preferred mode of operation of the analyzer 50, the target capture and annealing incubator 600 incubates the contents of the MTU 160 at about 60°C. For certain tests, it is important that the annealing incubation temperature not vary more than $\pm 0.5^{\circ}\text{C}$ and that amplification incubation (described below) temperature not vary more than $\pm 0.1^{\circ}\text{C}$. Consequently, the incubators are designed to provide a consistent uniform temperature.

The details of the structure and operation of the two embodiments of the rotary incubators 600, 602, 604 and 606 will now be described. Referring to FIGURES 19-23C, each of the incubators has housing with a generally cylindrical portion 610, suitably mounted to the datum plate 82, within an insulating jacket 612 and an insulated cover 611.

The cylindrical portion 610 is preferably constructed of nickel-plated cast aluminum and the metal portion of the cover 611 is preferably machined aluminum. The cylindrical portion 610 is preferably mounted to the datum plate 82 atop three or more resin "feet" 609. The feet 609 are preferably formed of Ultem®-1000 supplied by General Electric Plastics. The material is a poor thermal conductor, and therefore the feet 609 function to thermally isolate the incubator from the datum plate. The insulation 612 and the insulation for the cover 611 are preferably comprised of 1/2 inch thick polyethylene supplied by the Boyd Corporation of Pleasantown, California.

Receptacle access openings 614, 616 are formed in the cylindrical portion 610, and cooperating receptacle access openings 618, 620 are formed in the jacket 612. For incubators 600 and 602, one of set of access openings is positioned to be accessible by the right-side transport mechanism 500 and the other set of access opening is positioned to be accessible by the left-side transport mechanism 502. Incubators 604 and 606 need to be accessible only by the left-side transport mechanism 502 and therefore only have a single receptacle access opening.

Closure mechanisms comprising revolving doors 622, 624 are rotatably positioned within the openings 614 and 616. Each revolving door 622, 624 has a MTU slot 626 extending through a solid cylindrical body. The MTU slot 626 is configured to closely match the profile of the MTU 160, having a wider upper portion compared to the lower portion. A door roller 628, 630 is attached on top of each of the doors 622, 624, respectively. The revolving doors 622, 624 are

actuated by solenoids (not shown) which are controlled by commands from the assay manager program to open and close the doors 622, 624 at the proper times. A door 622 or 624 is opened by turning the door 622, 624 so that the MTU slot 626 thereof is aligned with the respective receptacle access opening 614, 616 and is closed by turning the door 622, 624 so that the MTU slot 626 thereof extends transversely to the respective access opening 614, 616. The cylindrical portion 610, cover 611, doors 622, 624, and a floor panel (not shown) constitute an enclosure which defines the incubation chamber.

The doors 622, 624 are opened to permit insertion or retrieval of an MTU into or from an incubator and are closed at all other times to minimize heat loss from the incubator through the access openings 614, 616.

A centrally positioned radial fan 632 is driven by an internal fan motor (not shown). A Papst, model number RER 100-25/14 centrifugal fan, available from ebm/Papst of Farmington, Connecticut, having a 24VDC motor and rated at 32 cfm is preferred because its shape is well-suited to application within the incubator.

Referring now to FIGURE 22, an MTU carousel assembly 671 is a preferred receptacle carrier which carries a plurality of radially oriented, circumferentially-arranged MTUs 160 within the incubator. The MTU carousel assembly 671 is carried by a top plate 642, which is supported by the cylindrical portion 610 of the housing, and is preferably actuated by a rotation motor 640, preferably a stepper motor, supported at a peripheral edge of on the top plate 642. Rotation motor 640 is preferably a VEXTA stepper motor, model number PK246-01A, available from Oriental Motor Co., Ltd. of Tokyo, Japan.

The MTU carousel 671 includes a hub 646 disposed below the top plate 642 and coupled, via a shaft 649 extending through the top plate 642, to a pulley 644. Pulley 644 is preferably a custom-made pulley with one hundred sixty-two (162) axial grooves disposed around its perimeter and is coupled to motor 640 through a belt 643, so that motor 640 can rotate the hub 646. Belt 643 is preferably a GT® series timing belt available from SDP/SI of New Hyde Park, New York. A 9:1 ratio is preferably provided between the pulley 644 and the motor 640. The hub 646 has a plurality of equally spaced-apart internal air flow slots 645 optionally separated by radially-oriented, circumferentially arranged divider walls 647. In the illustration, only three divider walls 647 are shown, although it will be understood that divider walls may be provided about the entire circumference of the hub 646. In the preferred embodiment, divider walls 647 are omitted. A support disk 670 is attached to hub 646 and disposed below top plate

642 in generally parallel relation therewith. A plurality of radially extending, circumferentially-
arranged MTU holding members 672 are attached to the bottom of the support disk 670 (only
three MTU holding members 672 are shown for clarity). The MTU holding members 672 have
support ridges 674 extending along opposite sides thereof. Radially oriented MTUs are carried
on the MTU carousel assembly 671 within stations 676 defined by circumferentially adjacent
MTU holding members 672, with the support ridges 674 supporting the connecting rib structures
164 of each MTU 160 carried by the MTU carousel assembly 671.

The MTU carousel assembly rotates on a carousel drive shaft to which the drive pulley
(644 in the illustrated embodiment) is attached. A carousel position encoder is preferably
mounted on an exterior end of the carousel drive shaft. The carousel position encoder preferably
comprises a slotted wheel and an optical slot switch combination (not shown). The slotted
wheel can be coupled to the carousel assembly 671 to rotate therewith, and the optical slot
switch can be fixed to the cylindrical portion 610 of the housing or top plate 642 so as to be
stationary. The slotted wheel/slot switch combination can be employed to indicate a rotational
position of the carousel assembly 671 and can indicate a "home" position (e.g., a position in
which an MTU station 676 designated the #1 station is in front of the access opening 614). A2
series encoders from U.S. Digital in Seattle, WA, model number A2-S-K-315-H, are preferred.

A heat source is provided in thermal communication with the incubator chamber defined
within the incubator housing comprising the cylindrical portion 610 and cover 611. In the
preferred embodiment, Mylar film-encased electrically-resistive heating foils 660 surround the
housing 610 and may be attached to the cover 611 as well. Preferred mylar film heating foils are
etched foils available from Minco Products, Inc. of Minneapolis, Minnesota and Heatron, Inc. of
Leavenworth, Kansas. Alternative heat sources may include internally mounted resistive heating
elements, thermal-electric heating chips (Peltiers), or a remote heat-generating mechanism
thermally connected to the housing by a conduit or the like.

As shown in FIGURES 19 and 22, a pipette slot 662 extends through the incubator cover
611, radially-aligned pipette holes 663 extend through the top plate 642, and pipettes slots 664
are formed in the support disk 670 over each MTU station 676, to allow pipetting of reagents
into MTUs disposed within the incubators. In the preferred embodiment of the analyzer 50 for
the preferred mode of operation, only two of the incubators, the amplification incubator 604 and
the hybridization protection assay incubator 606, include the pipette holes 663 and pipette slots